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Annual Status Report
NAGW-2954 (1535221)

Accomplishments of the Past Year

BIB Mixers

We have determined that the multi-pin "microprocessor style" packages in which current BIB devices are mounted will not meet our IF bandwidth spec of >2 GHz for a practical mixer. Hence we have started to repackage the Ga:Ge BIB devices in new microwave compatible packages. The smaller size of the microwave package mount necessitates cutting the BIB array down to include only the 3 smallest detectors: 0.2, 0.4, and 0.6 mm sq. A FIR beam incident at f/1.5 can be focussed on the smallest element for wavelengths shorter than 100 microns. A more typical (easier) beam convergence of f/3 will require 0.4 mm elements at 100 microns and 0.6 mm elements at 170 microns wavelength. Since the device capacitance (parasitic loss) scales with detector size, there is a tradeoff of speed of response and optical convenience. Our existing optics produce only the slower convergence beam, so we need to redesign the optical layout and are looking at long focal length all-reflective microscope objectives.

LO Sources

BIB detectors and the edge-coupled microbolometers being investigated independently by D. Prober at Yale and R. McGrath at JPL have restricted IF bandwidths, an order of magnitude less than what is possible with the Schottky-diode mixers we currently use for astronomical observations. Consequently the frequencies of the FIR laser lines must be close to the astronomical line of interest to be an effective LO. We have therefore begun a coordinated effort to discover and measure new FIR laser transitions lines in close frequency coincidence with important astrophysical lines. Most of this effort involves pumping isotopic variants of known good laser molecules with laser lines from isotopic variants of CO_2. We have been most successful in detecting new FIR lines in deuterated ammonia. One line in particular is very close to the frequency of the HD rotational line at 2675 GHz. Other lines are close to the FIR transitions of C II at 158 microns, ammonia at 125 microns, and O I at 63 microns. We are currently working to complete the absolute frequency measurements of isotopic NH_3 laser lines in the 2.0-5.0 THz region.

Plans for the Coming Year

BIB Mixer Evaluation

In FY95 the principal emphasis will be on finishing the evaluation of BIB detectors as far-infrared heterodyne mixers in the 2.0-5.0 THz region. Our goal is to have a working mixer before our September 1995 flight series on the KAO.

Transition-Edge Microbolometers

R. McGrath and coworkers at JPL and D. Prober and colleagues at Yale have collaborated to produce a superconducting mixer called the transition-edge microbolometer. First results near 500 GHz indicate a useful sensitivity of 650 K (DSB) and an IF bandwidth exceeding 2 GHz. McGrath intends to fabricate new devices for the 1200 GHz region, using either a twin-dipole or twin-slot geometry and a hyperhemispherical coupling lens. We have offered to help test the noise performance of these new devices upon availability. As mentioned in our original proposal, we have developed a complete receiver test system for cryogenic mixers in the 800-4000 GHz region, using a FIR laser LO and a multichannel AOS signal processor.

The low power level required from the LO with these devices makes consideration of a harmonic generator system practical, rather than using a laser as the LO. Any eventual space-based application of this technology would undoubtedly require the versatility of a tunable but well calibrated LO source. To investigate this possibility, we propose to construct a simple breadboard version of a 140 GHz tunable Gunn oscillator with a doubler or tripler feeding a variant of our cube corner harmonic generator. We currently use a functionally similar system for measuring the absolute frequencies of FIR laser lines. We estimate that microwatt power levels should be obtainable at THz frequencies which should be enough of an LO drive for the transition-edge microbolometers. Initial tests will be in the 1.0-1.5 THz band, close to the design frequency of the planned JPL devices. Of course we still have good laser lines in the range for mixer testing should the harmonic generated LO not be available in time. A successful demonstration of this mixer design and the harmonic LO would make it a strong candidate technology for the FIRST/SMIM project.

Bibliography

There were no refereed publications during the past year. There were, however, two oral presentations, parts of which described work being done under this grant:

1. "Far-infrared heterodyne spectrometer", R.T. Boreiko and A.L. Betz, in *Proc. of the Airborne Astronomy Symposium on the Galactic Ecosystem: From Gas to Stars to Dust,* eds. M.R. Haas, J.A. Davidson, and E.F. Erickson, in press (San Francisco: ASP 1994).

2. "Laser Spectroscopy of Molecules in Space", A.L. Betz and R.T. Boreiko, in *The Future of Spectroscopy: from Astronomy to Biology, In Honor of the 90th Birthday of Gerhard Herzberg,* Sainte-Adele, Quebec, Canada, Sept. 25-28, 1994.